STRUCTURAL GEOLOGY OF THE CONTINENTAL
MARGIN OFF PT. AÑO NUEVO, CALIFORNIA

David Dexter Frydenlund

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

STRUCTURAL GEOLOGY OF THE CONTINENTAL
MARGIN OFF PT. ANO NUEVO, CALIFORNIA

by

David Dexter Frydenlund

September 1974

Thesis Advisors: J. J. von Schwind
R. S. Andrews

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Palo Colorado-San Gregorio Fault Zone

Structural Geology of the Continental Margin Off Pt. Año Nuevo, California

by

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Submitted in partial fulfillment of the
requirements for the degree of

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Nine fault zones, including several possible offshore extensions of the Sur-Naciemento fault, were located and traced on the Continental Margin off Point Año Nuevo, California by seismic reflection profiling. Plate tectonic theory was combined with regional geology to arrive at the most plausible choice for the Sur-Naciemento fault zone and to generate a brief geologic history of the area.

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I. INTRODUCTION

A. OBJECTIVE

The objective of this study was to conduct a seismic survey of the continental margin off Pt. Año Nuevo, California. This survey, in combination with previous reconnaisance surveys, future surveys of a similar nature, and other geological and geophysical information should allow the accurate delineation of the fault zones in the area and provide some clue to their interrelationships. Of particular interest is the location of the offshore extension of the Sur-Naciemento Fault Zone, corresponding to the western boundary of the Salinian Block. The realization of this information should prove useful in helping to explain the genesis and evolution of the gross geologic structure of the region. This survey is a complement to an ongoing study of the structure and origins of the continental margin from Point Sur to the Farallon Islands.

B. AREA DESCRIPTION

The area surveyed extends from the Monterey Submarine Canyon in the south to approximately 80 Km north at latitude 37°20'N and laterally from the coast to a line approximately 70 Km offshore (Fig. 1).

In general, the area is a sedimentary basin on the Salinian Block. The basin is a post-middle Miocene syncline [Hoskins and Griffiths, 1971] with its major axis plunging

nearly continuously to the northeast. The proximity of granite onshore and offshore, particularly on the Farallon Ridge, lead to the tenative conclusion that the basement is granite throughout.

The basin is marked by evidence of a severe erosional history. There are generally marked angular unconformities between the Cretaceous and younger rocks. Middle Miocrene and older strata in the basin show much more evidence of faulting and folding than do younger strata which were comparatively free of evidence of such tectonic activity.

C. REGIONAL GEOLOGY

The region is probably part of the transform fault system along which the Pacific and North American Plates are slipping relative to each other (Fig. 2). About 30 Km to the east of the survey area is the San Andreas Fault which generally marks the boundary between the continental crust of the Salinian Block to the west and the oceanic crust of the Franciscan Assembage to the east.

The eastern edge of the survey area is dominated by the relatively well defined Palo Colorado-San Gregorio fault zone. This zone appears to extend to the south from the San Gregorio fault on land to the Carmel Canyon fault offshore and then to the Palo Colorado fault near Kaslar Point [Green *et al.*, 1973]. In the survey area it is approximately 4 Km wide. The main feature is a reverse fault which marks where the Miocene Monterey Formation has been thrust to the southwest over the Pleistocene marine terrace deposits

[Clark, 1970]. Offshore it separates the Pliocene Purisma Formation and the Miocene Monterey mudstone. Analysis of earthquake motion along the fault since 1969 indicates right lateral slip motion along nearly vertical fault planes [Green *et al.*, 1973].

Similar orientation and motion is noted in the numerous faults of the Monterey Bay fault zone. All these faults generally have a north west-southeast trend and many of them show disturbance of sediments up to within 6m below the sea-floor indicating that they have been active in the recent past [Green *et al.*, 1973].

The southern edge of the survey area is dominated by the Monterey Bay Canyon Systems (Fig. 3). The highly irregular and steep topography in the area makes seismic reflection profiling difficult at best and has prevented the tracing of even major faults across its axis.

In the western edge of the survey area is the offshore extension of the Sur-Naciemento fault zone marking the boundary between the Salinian Block and an offshore Franciscan Assemblage. The 1000m isobath passes through the western edge at the area in an irregular line extending northwest and southeast and roughly represents the offshore edge of a ridge which forms the western boundary of the sedimentary basin (Fig. 1). Just to the west of the survey area are several seamounts (Fig. 3). The most prominant of these, Pioneer and Guide, have been dredged and appear to be primarily basalt [Chesterman, 1952; Andrews, Personal Communication, 1974].

At the northern edge of the survey area is the Pioneer Canyon. To the north of that is the Gulf of the Farallons. In the Gulf, the continental shelf is divided into two structural platforms by the offshore extension of the Seal Cove Fault. To the east is the Golden Gate Platform marked by the San Andreas and Pilarcitos faults. To the west is the Farallon Platform which is characterized by thick Tertiary sediments bounded on their western edge by a ridge of Cretaceous granite rock which outcrops in the Farallon Islands [Cooper, 1971]. This ridge, which extends northward to the Cordell Bank, is thought also to extend southward into the survey area [Curray, 1965].

The granite basements, assumed to underlie the entire Salinian Block, imparts rigidity to the region and leads to a block-faulting structure in the over-lying sediments [Hoskins and Griffiths, 1971].

Most of the continental margin in and around the survey area has an unconsolidated sediment overburden. This sediment is mostly green and grey sands and muds [Uchupi and Emery, 1963].

Two regions of magnetic anomaly are found in the survey area. The Pigeon Pt. High along the edge of the San Gregario fault zone and the Santa Cruz High over the ridge along the upper edge of the continental slope. The Farallon Islands to the north are also a region of high magnetic anomaly.

D. TECTONIC DEVELOPMENT

The Sur-Naciemento fault zone which lies on the western edge of the survey area has been interpreted by Page [1970] as being a former subduction zone. This fault zone and a similar fault and subduction zone separating Franciscan and Sierran granitic rocks under the Great Valley may represent an initially continuous plain which was offset by the San Andreas fault. Wentworth [1968] has suggested a minimum offset of approximately 600 Km beginning in the late Cretaceous.

It has been suggested by Silver, Curray and Cooper [1971], that the first stage in the late Cretaceous involved lateral movement along the ancestral trend of the San Andreas fault (Fig. 4). Atwater [1970] suggests under thrusting beneath the Central California Continental Margin was occurring from the early Tertiary until the early Miocene when the Pacific and North American Plates came into contact at which time the under thrusting ceased. The remaining offset of the San Andreas fault system has occurred since the early Miocene, possibly in two stages as suggested by Suppe [1970]. The sedimentary basin of interest probably formed during this period of time.

E. PREVIOUS AREA INVESTIGATION

The area surveyed has been of interest, for various reasons, for a long period of time. Soon after California became part of the United States of America, the Coast and Geodetic Survey commenced bathymetric work which has continued to the present. In 1891, the U.S.S. ALBATROSS made a

transect while surveying for a submarine cable route. The ALBATROSS returned to the area in 1904 and surveyed sporadically until 1920 concerning itself mostly with biology, but gathering general geological data as well.

Investigation was renewed by the Scripps Institution of Oceanography [Shepard and Emery, 1941; Shepard, 1948] and the California Academy of Sciences [Hanna, 1952; Chesterman, 1952].

The major effort began in the 1960's [Uchupi and Emery, 1963; Martin, 1964; Curray, 1965; Rusnak, 1966; Martin and Emery, 1967; Hoskins and Griffiths , 1971; Silver *et al.* 1971; Green *et al.* 1973; Spikes, 1973]. To date, the investigations have been essentially reconnaisance studies concerned with the major regional structures of the central California shelf.

The land geology of adjacent and related structures has been studied at great length, starting with the initial mapping by Johnson in 1855. Of particular interest is the work of Clark (1970) who described the onshore geology in the region near Pt. Año Nuevo. The Sur-Naciemento fault system has been studied at some length most notably by Trask (1926) and Page (1970).

Offshore, the most notable surveys have been the fairly general works of Shepard, Martin, Emery, and Rusnak, who concerned themselves with the topography of the continental margin; Curray, who concerned himself with the general geologic structure of the region; Hoskins and Griffiths, who

looked at the stratigraphy of the area in question; Green *et al.*, who depicted the crustal structure of Monterey Bay in some detail, giving special attention to offshore faults; and Spikes, who did a gravimetric survey of the near shore region from Pt. Año Nuevo to Santa Cruz.

II. COLLECTION OF DATA

A. SURVEY PROCEDURE

The data analyzed in this paper was gathered in three separate cruises using U. S. Navy AGOR class oceanographic research vessels operated by civilian crews (Fig. 5).

The first of these cruises was in November of 1972 on the USNS BARTLETT (T-AGOR 13). This cruise was a co-operative effort of the U. S. Geologic Survey (USGS) and the Naval Postgraduate School (NPS). It was primarily a reconnaisance survey of the continental margin from the Farallon Islands to Pt. Sur. Segments of three tracks from this cruise were in the area of interest. The primary seismic information utilized from this cruise was obtained using a USGS Marine Geology Division 160 KJ arcer system. Hydrophone signals were processed with a 25-98 Hz bandpass filter. A 4-sec firing rate was used throughout.

The second cruise was in November of 1973 on the USNS DE STEIGER (T-AGOR 12). This cruise was an NPS continental margin study from Pt. Sur to Half Moon Bay. The third cruise was on the USNS BARTLETT in April of 1974 and was undertaken to augment data from the previous cruises.

On the second and third cruises the primary seismic information utilized came from a 30 KJ Teledyne Arcer Seismic System. The system was operated with a 4-sec firing rate at 16 KJ. Hydrophone signals were processed with a 63-125 Hz bandpass filter.

On all three cruises, a 3.5 KHz normal incidence sonar system was run for high resolution of surface sediment and a proton precession magnetometer was towed. Ship speed varied from 5 to 8 knots depending on weather conditions.

B. NAVIGATION

In the area surveyed, accurate navigation was a problem. A combination of factors served to degrade the accuracy of position finding. Visual navigation was hampered by the prevelance of coastal fog and the paucity, especially at night, of prominent landmarks. LORAN coverage in the area is limited to one dependable line. Much of the survey was conducted outside effective radar navigation range. During the third cruise, the Navigational Sattelite (NAVSAT) equipment installed on the AGOR was erratic in its performance.

In general, the navigation was handled by using NAVSAT as the primary source. This was used to correct a plot which usually consisted of dead reckoning and one LORAN line. When possible, visual and radar lines were added.

The navigation was checked and hand corrected in the laboratory using all available inputs to rectify errors. Within 10 Km of shore, the rectified navigation is generally accurate to ±½Km. This accuracy degrades steadily offshore to ± 3-4 Km in the western edge of the survey area.

III. ANALYSIS OF DATA

A. INTERPRETATION NOTES

Sound speed in the water column was determined from an XBT trace. The average speed for the water column was approximately 1.5 Km/sec. No sound speed data was available for the sub-bottom layers in the sedimentary basin in question. After considering the age, depth, and probable composition of the sedimentary rock, it was decided to use a value of 3.0 Km/sec as the mean speed. Any depths given in meters will be based on these two assumptions. All travel times given in the body of this paper are oneway travel times.

Insufficient data was available to determine whether faults in the area were dip-slip or strike-slip. In all cases where up or down is indicated along a fault it is a best estimate of the present relationship of the bedding on either side. The mechanism by which the juxtaposition took place is not implied. Faults in the area are probably mainly strike-slip [Green *et al.* 1973] with some possible dip-slip motion.

In analyzing the major faults, the assumption was made that they would form continuous, near vertical traces, parallel or nearly parallel to the Palo Colorado-San Gregorio fault. This assumption was based on the nature of previously identified faults in the region and the expected block faulting effect of the under-lying Salinian Block. When no

evidence to the contrary was available, this assumption was used to infer the location of fault zones.

High resolution data was used only occasionally to verify the locations of surficial evidence of faulting such as scarps. Magnetometer data was used to aid in the identification of faults from one trackline to the next by comparing anomalies at fault boundaries.

B. GENERAL STRUCTURE

The area studied can be divided into three basic structures; a ridge on the eastern edge, a central sedimentary basin, and a ridge on the western edge (Fig. 6). The entire area has been subjected to moderate to complex folding and faulting. Although they are all inter-related, each of the structures and individual major fault zones will be discussed separately. Features discussed can be seen in Fig. 7 thru Fig. 18.

1. The Eastern Ridge

The eastern ridge is probably an extension of the Farallon Ridge and is, therefore, probably granitic rock. In the survey area, its boundaries correspond well to those of the Pigeon Point region of high magnetic anomaly. The ridge is complexly folded and faulted, specially in the first 10 Km on the western side of the Palo Colorado-San Gregorio fault zone. The sediment over-lying the ridge is thin. Generally the deepest identifiable sedimentary layers varied from 0.1 to 0.2 sec of one-way travel time (300 to 600m in thickness) depending on the degree of folding.

These sedimentary layers are probably of the same nature as the Pleistocene, Pliocene, Miocene, Upper Cretaceous Marine series seen on land to the west of the San Gregario fault north of Point Año Nuevo. The complex folding and faulting of the ridge precludes any realistic extension of the land structure to the sub-bottom based on available profiles. Most of the faults on the ridge penetrate to the basement. The western edge of the ridge drops off relatively steeply (10 to 15° slope) into the sedimentary basin.

2. The Sedimentary Basin

A post-Middle Miocene syncline dominates the center of the survey area. A structure contour map of the deepest identifiable horizon (believed to be basement)(Fig. 19) shows the major axis plunging fairly regularly (approximately 3° slope) to the northeast. On the syncline axis, sediment thickness increases from approximately 0.1 sec (300m) near Santa Cruz in the south to 1.0 sec (3 Km) at 37°20'N. As it deepens, the basin broadens from its 20 Km width in the south to slightly more than 60 Km at 37°20'N. Evidence of faulting is found throughout the basin. Most of the faults in the sedimentary basin appear to be inactive and few penetrate to the surface layers. The slope of the western side of the basin rises at a more moderate angle (6 to 10°) to the western ridge. A good description of the most probable basin stratigraphy is available in Hoskins and Griffiths (1971).

3. The Western Ridge

Over the western ridge the sediment thins until the sedimentary layer is thinner than the seismic source bubble

pulse. Sediments there are probably less than 100m. The under-lying rock is lacking in structural detail and is probably high grade metamorphic or granitic. Hoskins and Griffiths (1971) indicate that it is probably Cretaceous. Curray (1966) indicates that it is probably granite.

The ridge has an irregular surface with several small sedimentary basins in evidence (Fig. 11). Several faults of varying ages are in evidence along the ridge. The ridge averages 15 to 20 Km in width and terminates at, or is truncated by, the Ascension Canyon and the Pioneer Canyon in the south and the north, respectively. The ridge corresponds generally to the region of magnetic anomaly known as the Santa Cruz High (Fig. 6).

C. FAULT ZONES

Nine fault zones were located and traced in the survey area. Each zone was numbered starting from shore (Fig. 20). The faults divide the area into two regions. Those to the east of fault 4 are in a region of complex folding and faulting and seem to be approximately parallel to the Palo Colarado San Gregario fault. From fault 4 to the west, the faulting and folding are less complex. The faults here seem to radiate from a common point in Monterey Bay. In the following sections each of the faults will be discussed separately. The locations of the designated faults can be seen in the seismic profiles in Fig. 8 through 18.

1. <u>Fault No. 1</u>

Fault 1 is the previously known and charted Palo Colorado-San Gregario fault zone in the southern part of the survey area. It is a series of high angle faults spread over a 4 Km width. To the north of Pescadero Point and into Half Moon Bay it is a wider series of faults. Fault 1, as shown on Figs. 8, 9 and 18, is slightly to the west of the charted location of the Seal Cove fault and may be the Seal Cove fault or a related parallel fault. The turn points on the track lines were at the fault line and the exact nature of the interrelationships of the faults near shore in Half Moon Bay was obscured.

2. <u>Fault No. 2</u>

In the southern portion of the survey area, fault 2 is a zone of numerous high angle faults approximately 5 Km wide. Generally, reflectors on the west side are lower than their counterparts on the east. In the complex folding off Pigeon Point the location of the fault is obscure. Assuming a linear trace, it is thought to pass approximately 3 Km off Pigeon Point and connect to a less complex fault zone to the north.

The northern portion of the fault zone generally appears as one or two distinctive faults. The vertical displacement in the north seems to be the opposite of that to the south with the western side being generally elevated. The irregularity from track to track of the relationship of strata on opposite sides of the fault, with first one side

then the other in an elevated position, suggests that the apparent vertical displacement of strata is probably a result of the horizontal displacement of strata of irregular contour by strike-slip rather than a result of vertical displacement by dip-slip. Throughout the survey area, the fault zone penetrates from near surface to the apparent basement. No evidence was seen of recent activity of the fault.

3. Fault No. 3

Throughout the survey area, Fault 3 appears as a pair of nearly parallel faults with separation varying from 0.5 to 5 Km. Generally, the area between the faults is elevated with respect to the surrounding strata. The trace of the fault is distinct except in the area of complex folding and faulting off Pigeon Point. The faulting extends from approximately 300 m below the sea floor into the apparent basement and approximately parallels the western edge of the crust of the eastern ridge.

4. Fault No. 4

Fault 4 marks the western extreme of the area of complex folding and faulting off Pigeon Point. It is readily identified throughout the survey area except at the extreme southern end where it becomes obscure near the Ascension Canyon. The fault generally shows as a single high angle fracture with the west side depressed and the east side elevated. In the north it extends from approximately 300m below the sea floor into the apparent basement while in the south it reaches the surface. It appears to form an eastern

boundary for two small branches of Ascension Canyon. For a short distance it appears to break the surface with a definite scarp in evidence (Fig. 14).

5. Fault No. 5

Fault 5 is a distinct trace throughout the central section of the survey area being less distinct in the south and north. The fault shows as a single fracture with the western side depressed. In the north it extends from about 200m below the sea floor to the apparent basement. In the south it appears to reach the surface but there is no evidence of scarp. This fault appears to merge with fault 4 near Ascension Canyon.

6. Fault No. 6

Fault 6 appears as a very definite double fault in the north, extending from very near the sea floor to the basement (Fig. 11). To the south it is less distinct and generally appears as a single fracture. It appears to reach basement throughout. To the south it is generally found 200 to 400m below the sea floor. Throughout its length, it is depressed on the western side. Its location is obscure in the central section of the survey area.

7. Fault No. 7

Fault 7 is not easily seen in any of the profiles; its trace is faint but discernible in all of the profiles. This fault appears as a single fracture which is confined to the middle of the sedimentary layers. It generally extends from 500m below the sea floor to 200 to 1500m above

the basement. The western side is generally elevated through several lines indicated a reverse orientation.

8. Fault No. 8

This fault lies near the crest of the western ridge. Its vertical extent is from near surface or surface into the basement. It appears as one to three fractures with the west predominantly depressed. Occasionally a surface scarp is in evidence (Fig. 10). The trace is very distinct in the north becoming obscure as Ascension Canyon is approached.

9. Fault No. 9

Appearing on the western slope of the western ridge only a short section of this fault was seen. It seems to extend from the sea floor to the basement. From one to three distinct fractures are seen with the west predominantly elevated. Possible surface scarps were noted in the high resolution profile corresponding to Fig. 9.

IV. DISCUSSION

A. SUR-NACIEMENTO FAULT ZONE

It has been suggested, based on the granitic composition of the Farallon Ridge, that the Sur-Naciemento fault zone passes to the west of the Farallon Islands. If the Santa Cruz High represents a granitic composition of the western ridge in the survey area, following the same logic, the Sur-Naciemento fault should pass to the west of the ridge. This would place the fault much further offshore than has been previously suggested. Verification of the nature of the basement material on the western ridge would be useful in determining its relationship to the regional geology. Such verification might be obtained through dredging the sourth wall of the Pioneer Canyon or the northwest walls of Ascension Canyon.

If the Sur-Naciemento fault passes to the west of the Santa Cruz High, it is outside the area of this survey. If the ridge is made up of high grade Cretaceous metamorphic rock, or, if the presence of Mesozoic granitic rocks to the west of the Sur-Naciemento fault zone is accepted, one of the nine fault zones noted in the survey is probably the Sur-Naciemento.

Fault 4 appears to be amongst the most important faults in the area. As was previously noted, it marks the dividing line between the complex folding and faulting to the east and the simpler basin to the west. If extended straight to

the south it meets the Sur-Naciemento fault at Point Sur. In the survey area, it generally lies along the west edge of the eastern ridge which is probably the southern extension of the Farallon Ridge. If faults 4, 6, 7, 8 and 9 are all extended in straight lines they converge in a small area centered at 36°42'N, 122°12'W (Fig. 21). This area is approximately 5 Km north of the axis of the Monterey Submarine Canyon and 6 to 8 Km to the west of an earthquake epicenter cluster reported by Green *et al.* (1973). Several of the faults show evidence of possible recent activity.

Fault 4 seems to be a high angle reverse fault with the western side depressed. Faults 5 and 6 show similar relative displacement. These could represent a subduction zone. The suggestion by Page (1970) that the Sur-Naciemento is a subduction zone with successive movements in several different epochs makes faults 4, 5 and 6 attractive candidates for the Sur-Naciemento. Page (1970) noted that the Sur-Naciemento fault on land shows modest dip separation in the Miocene and younger formations. Similar apparent displacement is noted in faults 4, 5 and 6.

The hypothesis that one or more of these faults is an extension of the Sur-Naciemento would be reinforced by the determination that the western ridge is an upper Jurrasic to Mid-Cretaceous Franciscan eugosynclinal assemblage rather than Mesozoic granite.

If the western ridge is metamorphic rock, faults 8 and 9 also fit the general pattern of the Sur-Naciemento fault

as described by Page (1970). To match the Sur-Naciemento on land a missing sedimentary zone would be required to the west and the apparent orientation of fault 9 is the reverse of that expected.

B. PIGEON POINT AREA

The region of complex faulting and folding off Pigeon Point is important in the overall regional structure. If fault 4 has been a region of compression and subduction through the late Cenozoic, it is plausible that these folds and faults are a product of this compressional stress. If fault 1 or faults 1 and 4 have been experiencing strike slip motion, the folds may be drag-folds. The features found off Pigeon Point are probably a product of both these mechanisms.

C. SUMMARY

If the western ridge is granite, the Sur-Naciemento fault probably passes to the west of the survey area. On the other hand, if the western ridge is high grade metamorphic rock, the Sur-Naciemento fault zone is probably a combination of faults 4 and 5. The existence of the synclinal basin could then be attributed to a depression caused by the subduction of oceanic crust at the edge of the continental plate from the Tertiary or late Cretaceous until the early Miocene. At this point subduction ceased and strike-slip began along the plate boundaries. From then until the present, the area moved northward and filled with sediment. It probably

experienced alternate deposition and erosion during periods of uplift in the Pliocene and mid-Pleistocene. Some of the high angle faults were probably formed during these periods.

Strike-slip motion while centered in the San Andreas fault system, also occurred in subsidiary faults including those in the survey area. Fault 1, the Palo Colorado-San Gregorio, is known to be right-lateral strike-slip.

The folding and faulting in the Pigeon Point fault zone probably occurred in the mid-Pleistocene as a function of uplift, compression, and drag folding.

D. FUTURE WORK

The location and orientation of fault zones on the continental margin to the south of Monterey Canyon should be analyzed and projected through the canyon and on to the north. A seismic profiling program carried out from 37°20'N to 37°40'N and from the coast to 123°25'W would provide a connection between the survey in this report and that of the Gulf of the Farallons [Cooper, 1971]. Such a survey would allow confirmation of the location of the Farallon Ridge and indicate whether the western ridge continues beyond Pioneer Canyon. The northern reaches of the basin could be charted and the fault zones traced further to the north. Of particular interest are the traces of faults 4, 5, 7 and 8 and an answer as to whether faults 4 and 5 pass to the east or the west of the Farallon Islands. Dredging should be conducted as previously noted. The area shows signs of recent seismic activity, though no reference to earthquake epicenters in

the area was found. Bottom seismographs in the survey area specially near faults 4, 5 and 6 would indicate whether the area is still seismically active.

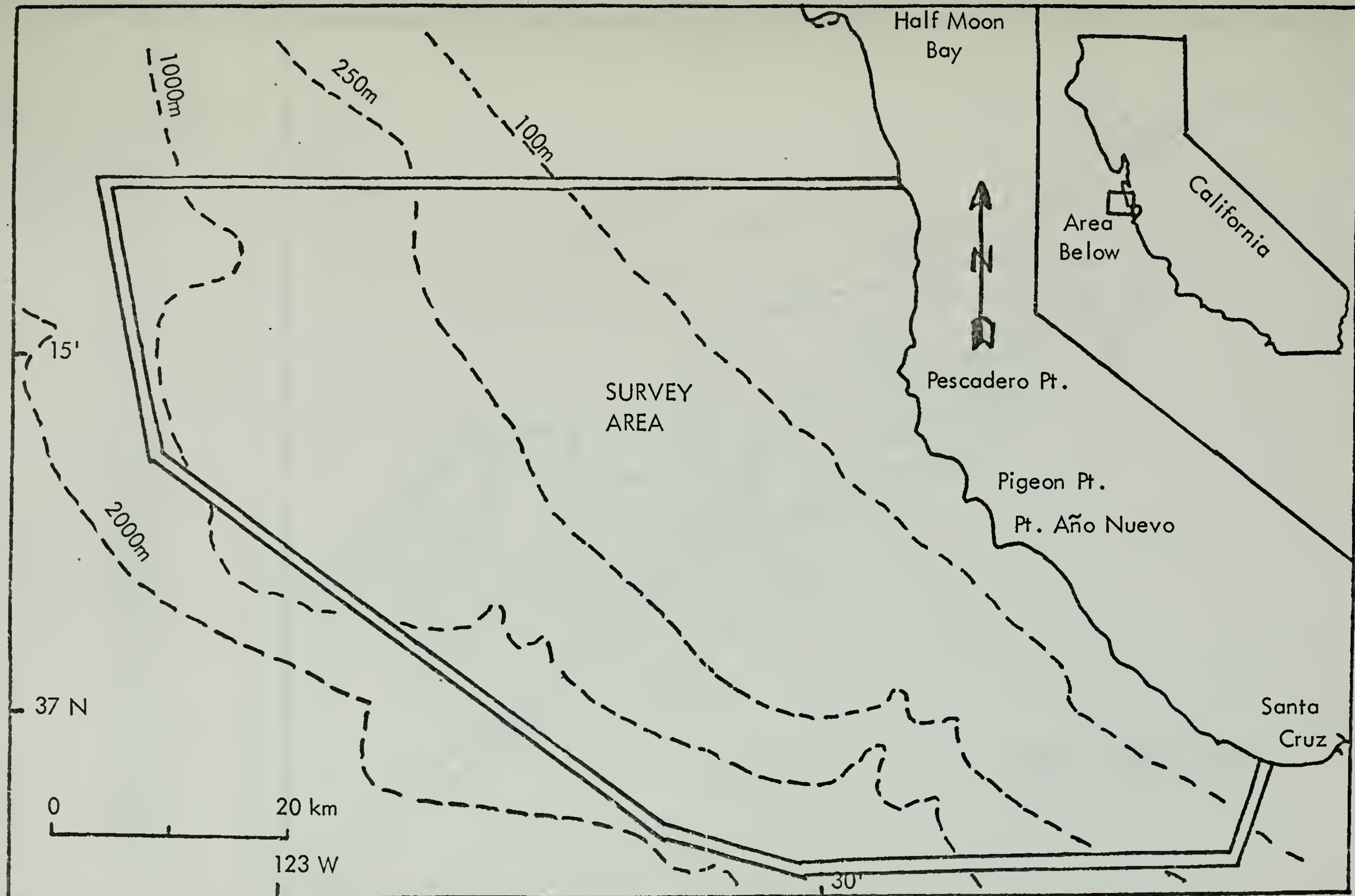

Figure 1. Survey Area Location and Limits with Approximate Bathymetry.

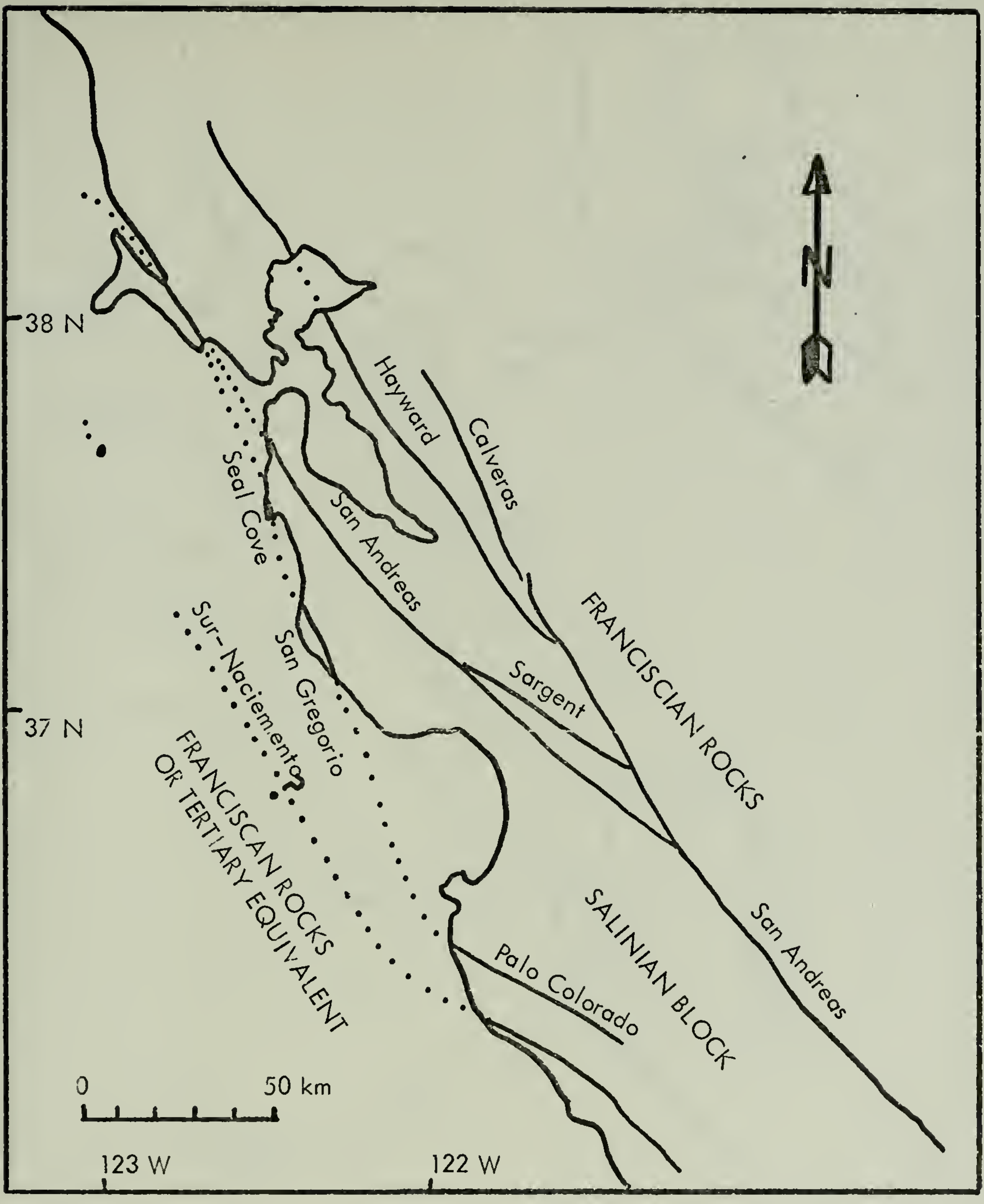

Figure 2. Regional Map of Central California Showing Major Fault Zones. After Brown and Lee (1971), Silver *et al.* (1971), Cooper (1971).

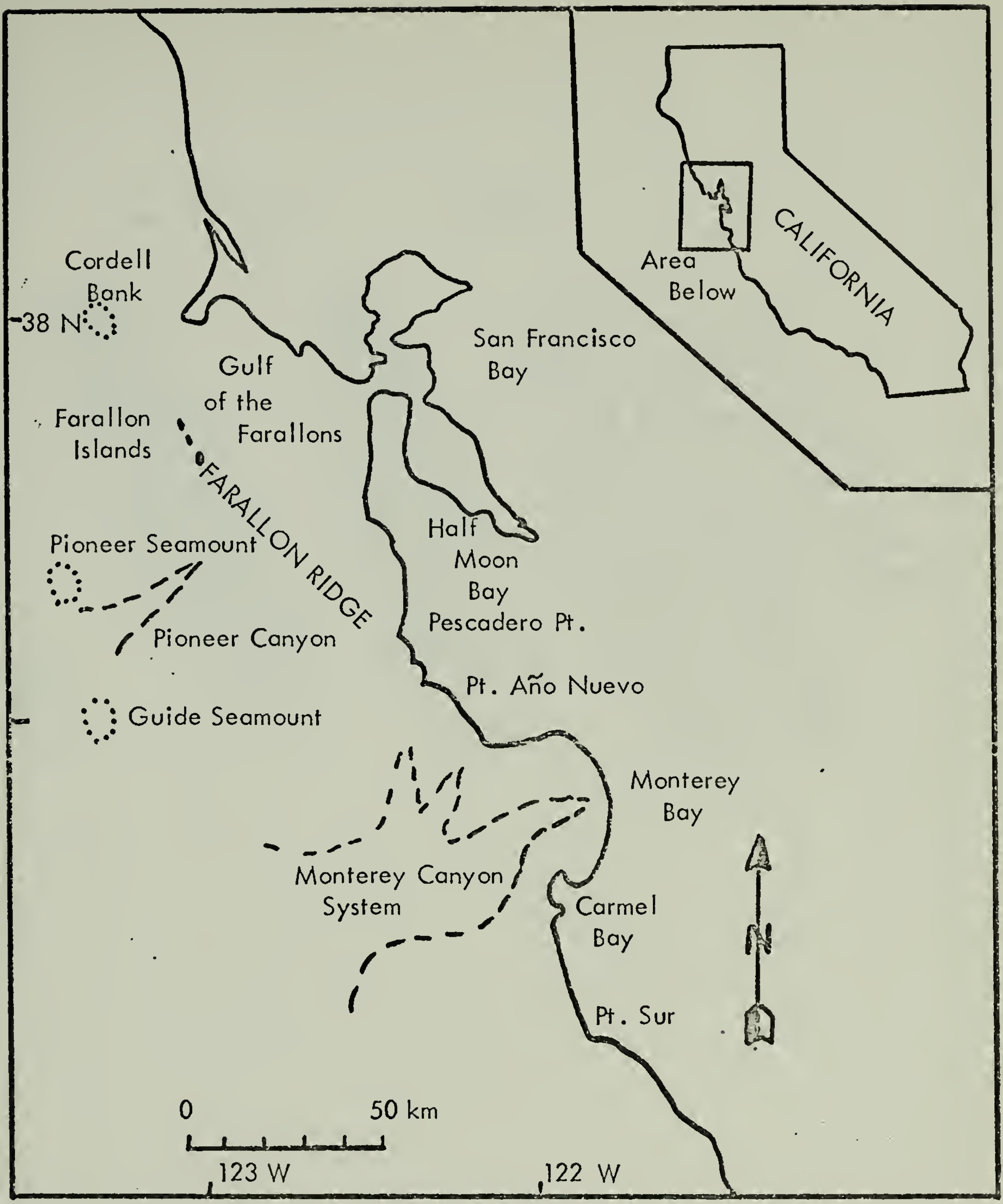

Figure 3. Regional Map of Central California Showing Place Names.

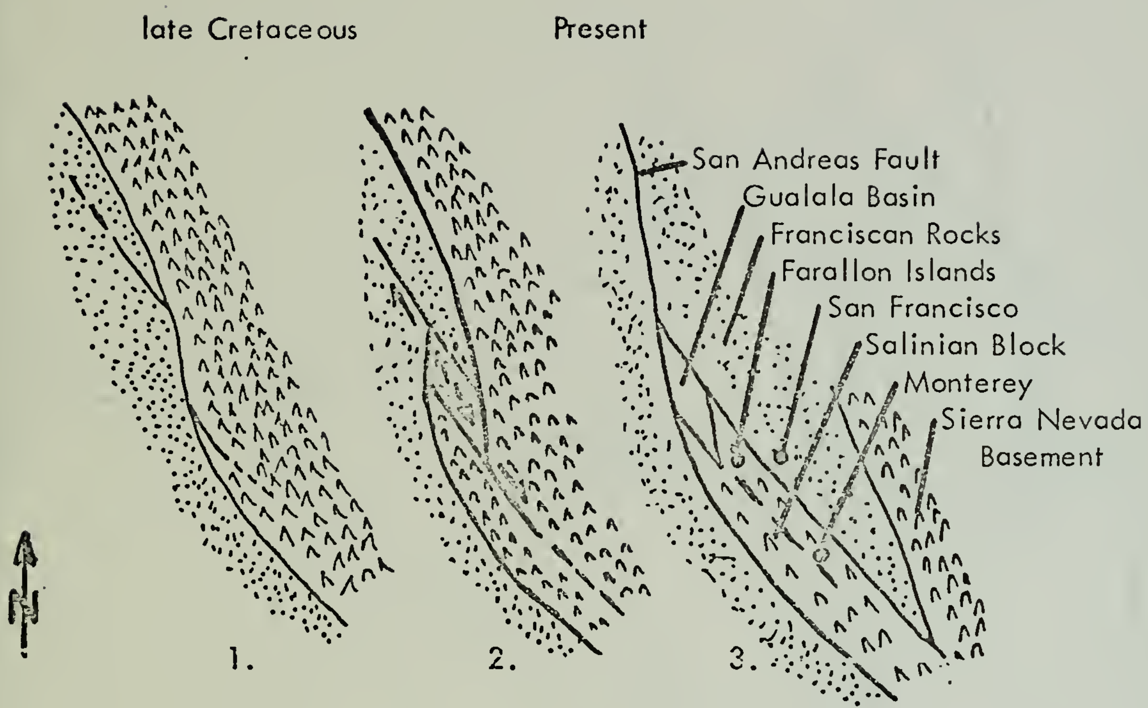

Figure 4. Hypothetical Regional Development as a Basalt Floored Rift Resulted From Right Slip Movement Between Echelon Faults in Late Cretaceous Time. After Silver et al. [1971]

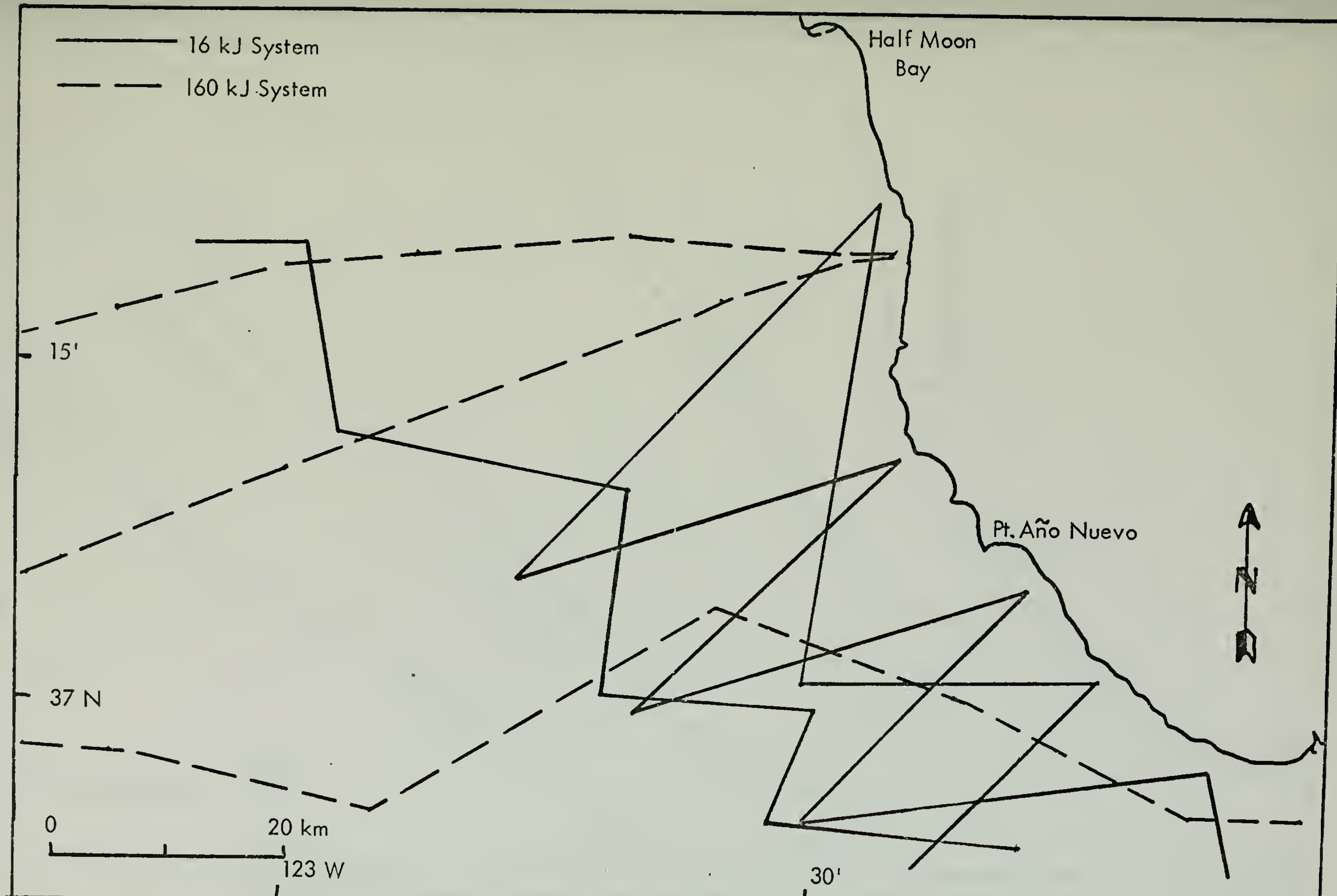

Figure 5. Location of Ships Tracks Used in the Investigation.

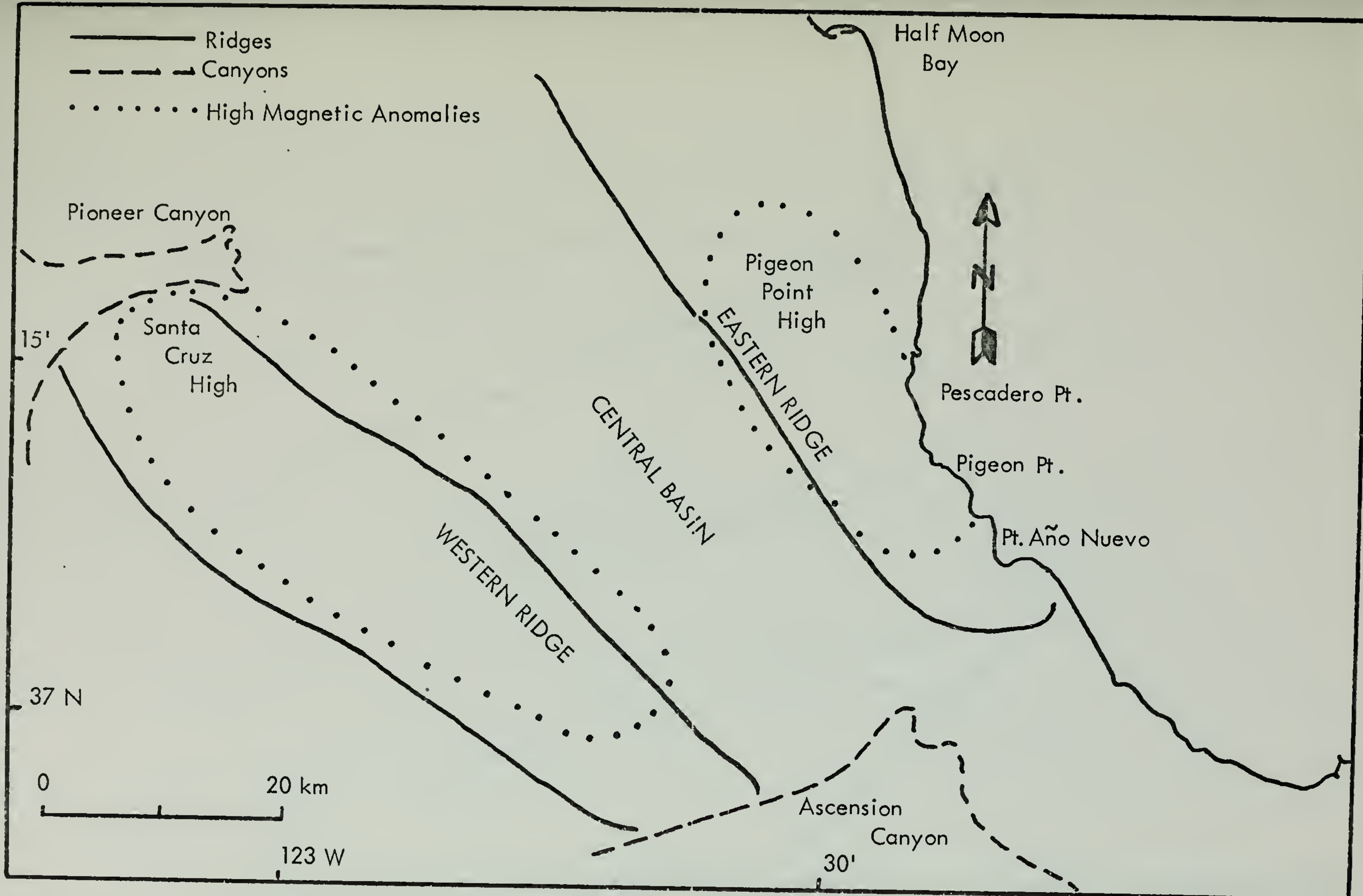

Figure 6. Map of Structural Provinces in the Survey Area.

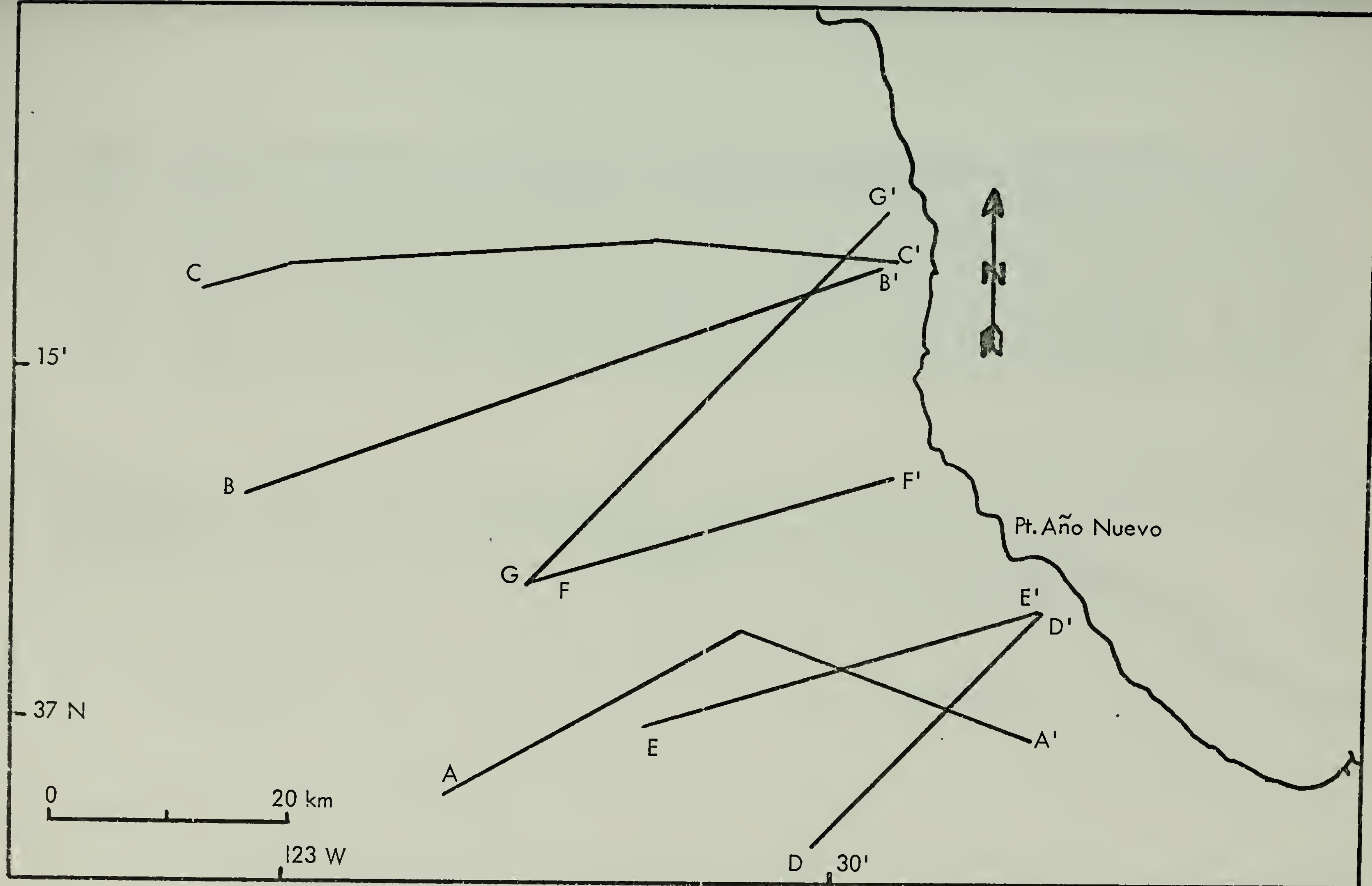

Figure 7. Location of Selected Profiles.

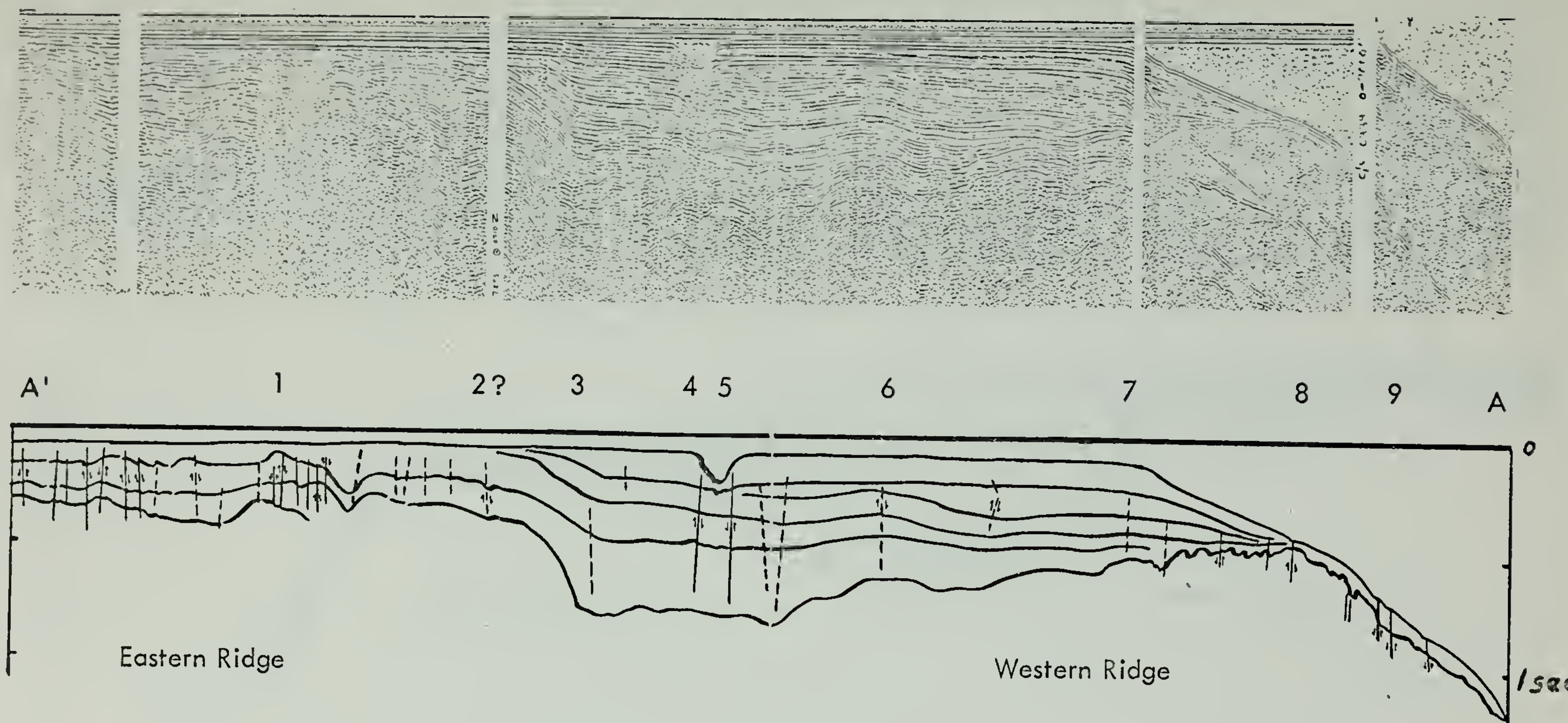

Figure 8. Profile A A' Seismic Record and Line Drawing with Faults Numbered.

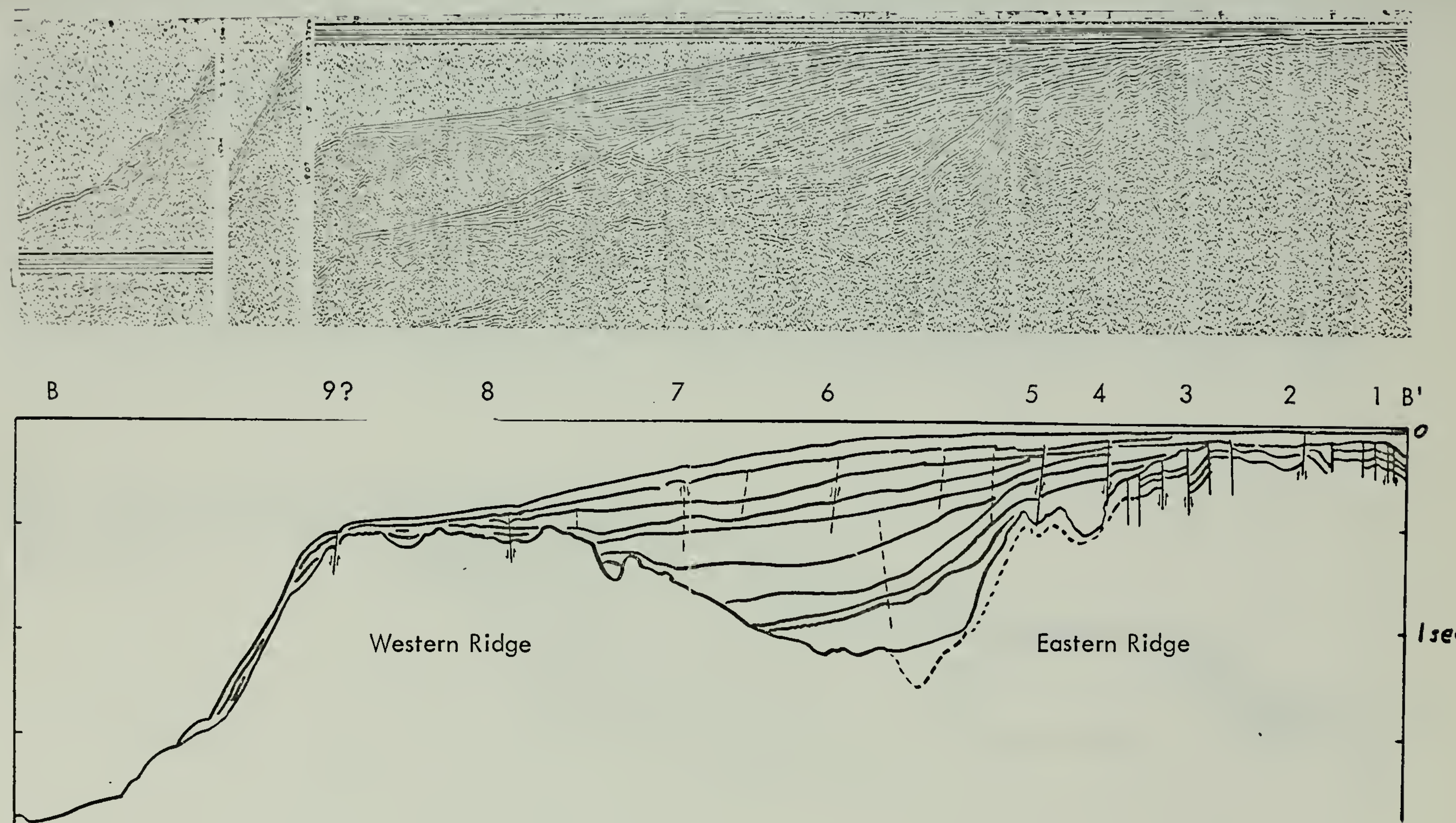

Figure 9. Profile B B' Seismic Record and Line Drawing.

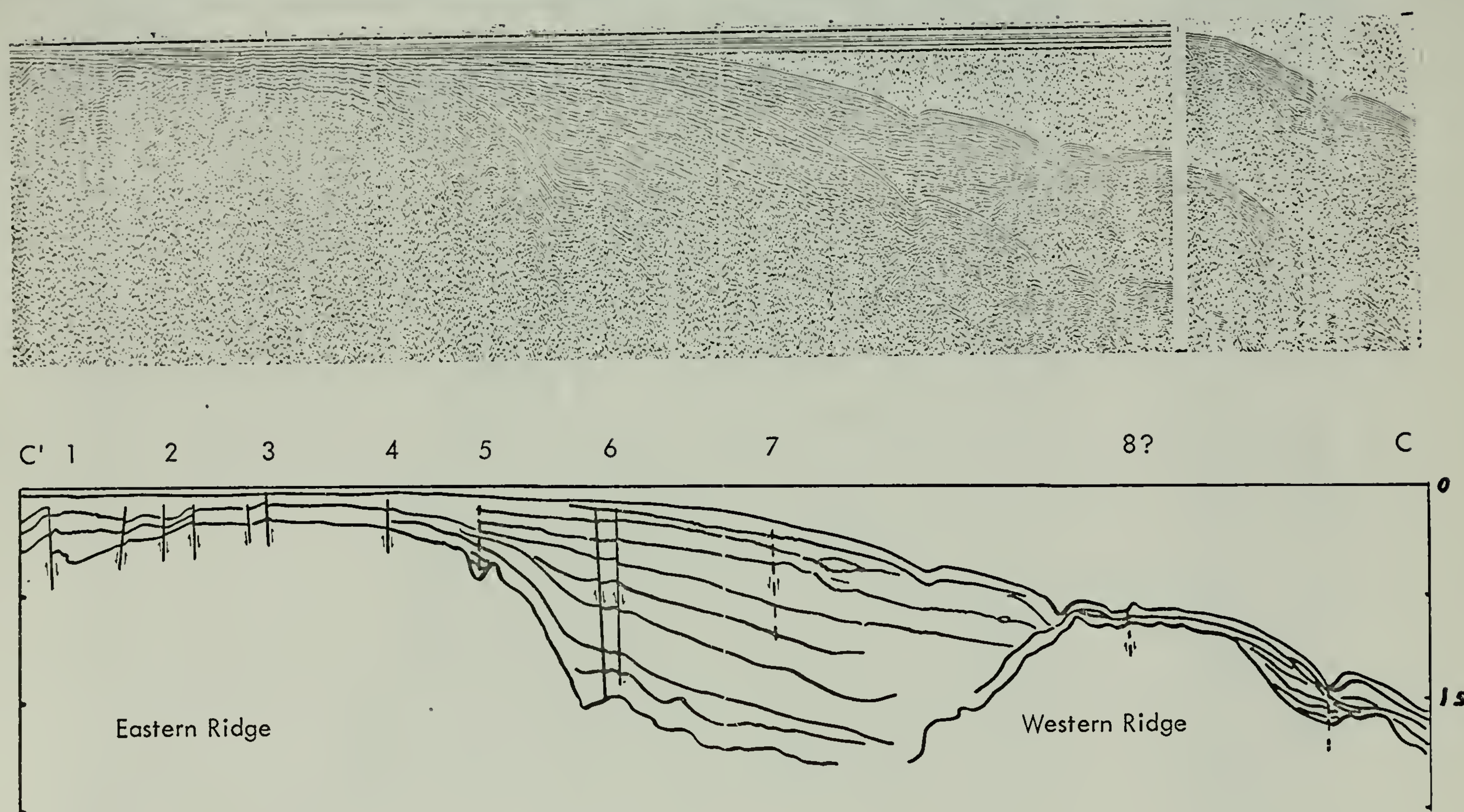

Figure 10. Profile C C' Seismic Record and Line Drawing.

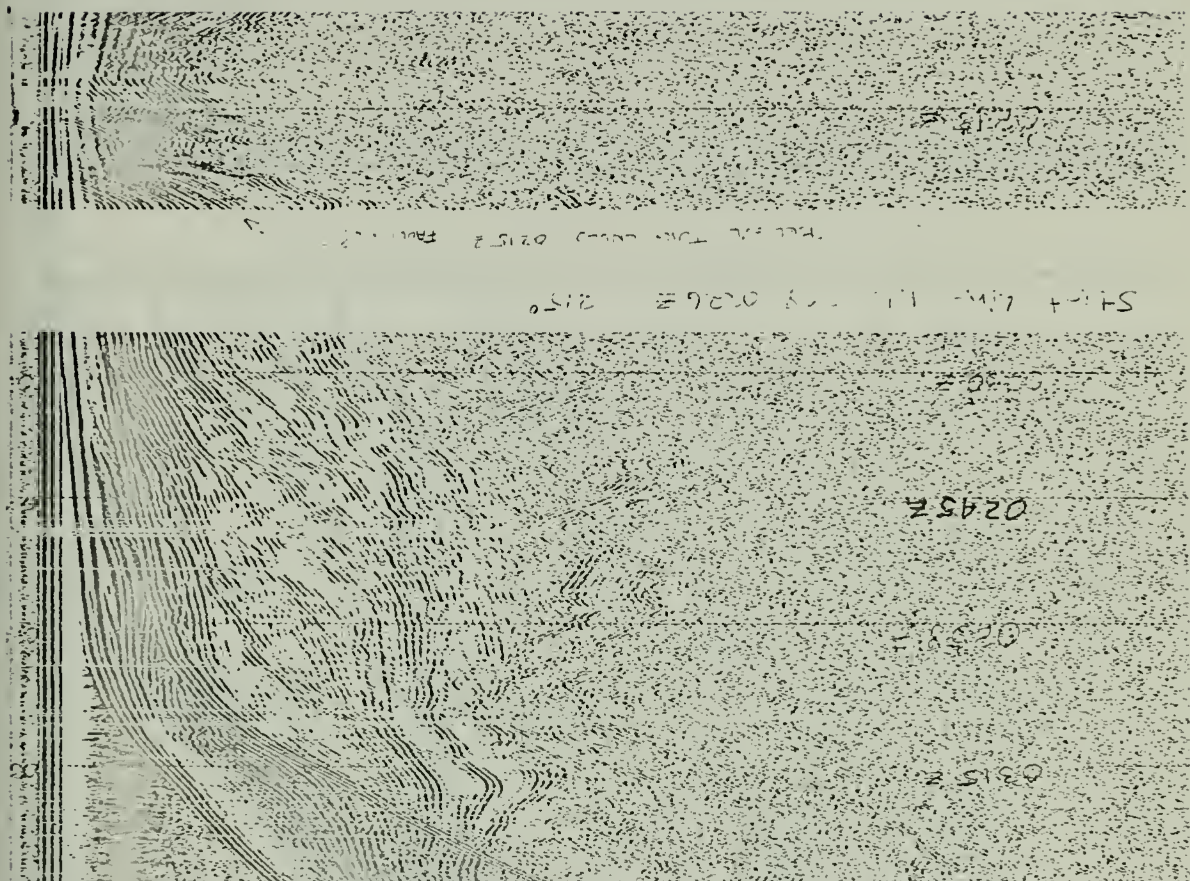

Figure 11. D D' Seismic Record.

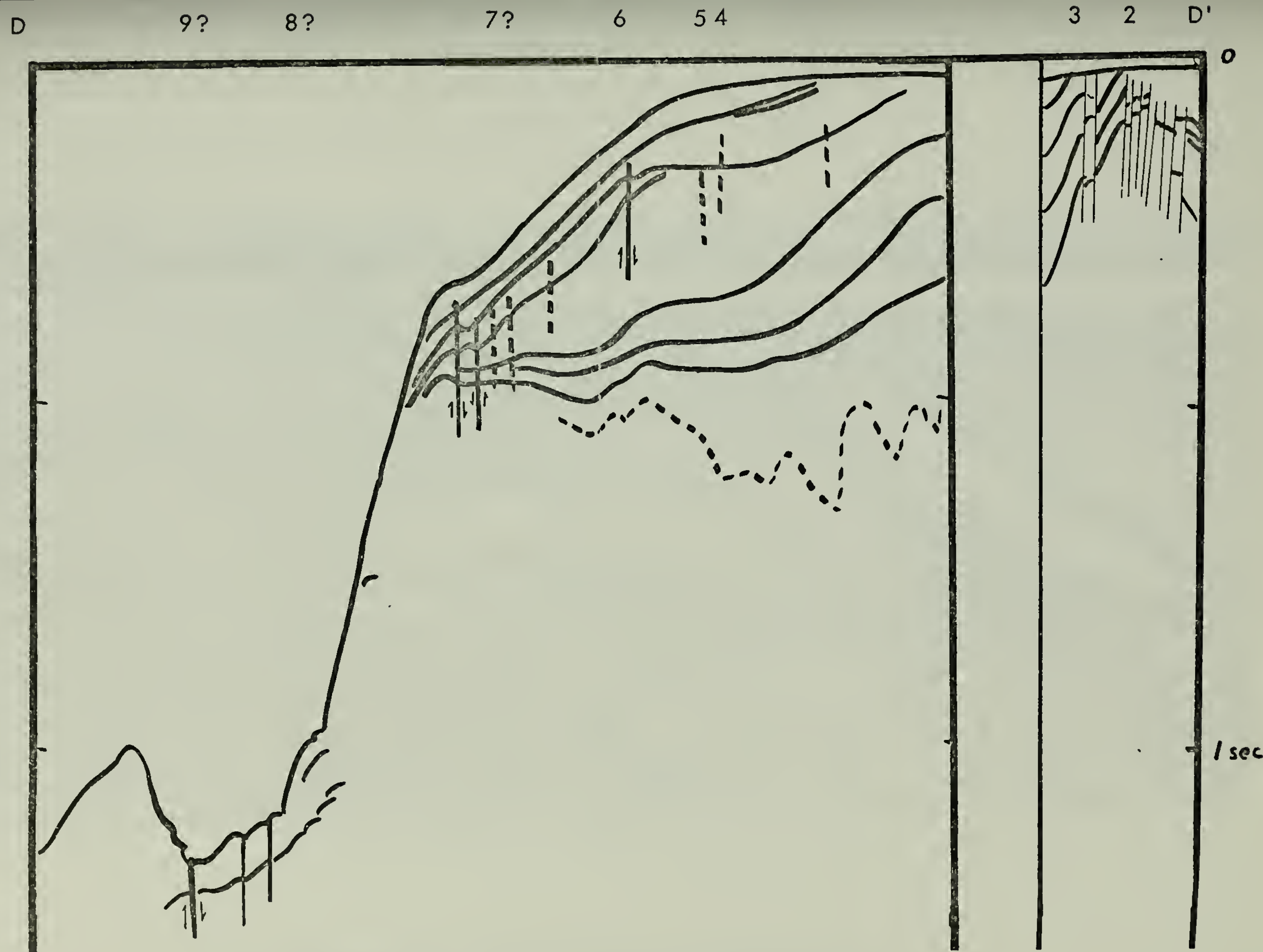

Figure 12. Profile D D' Line Drawing.

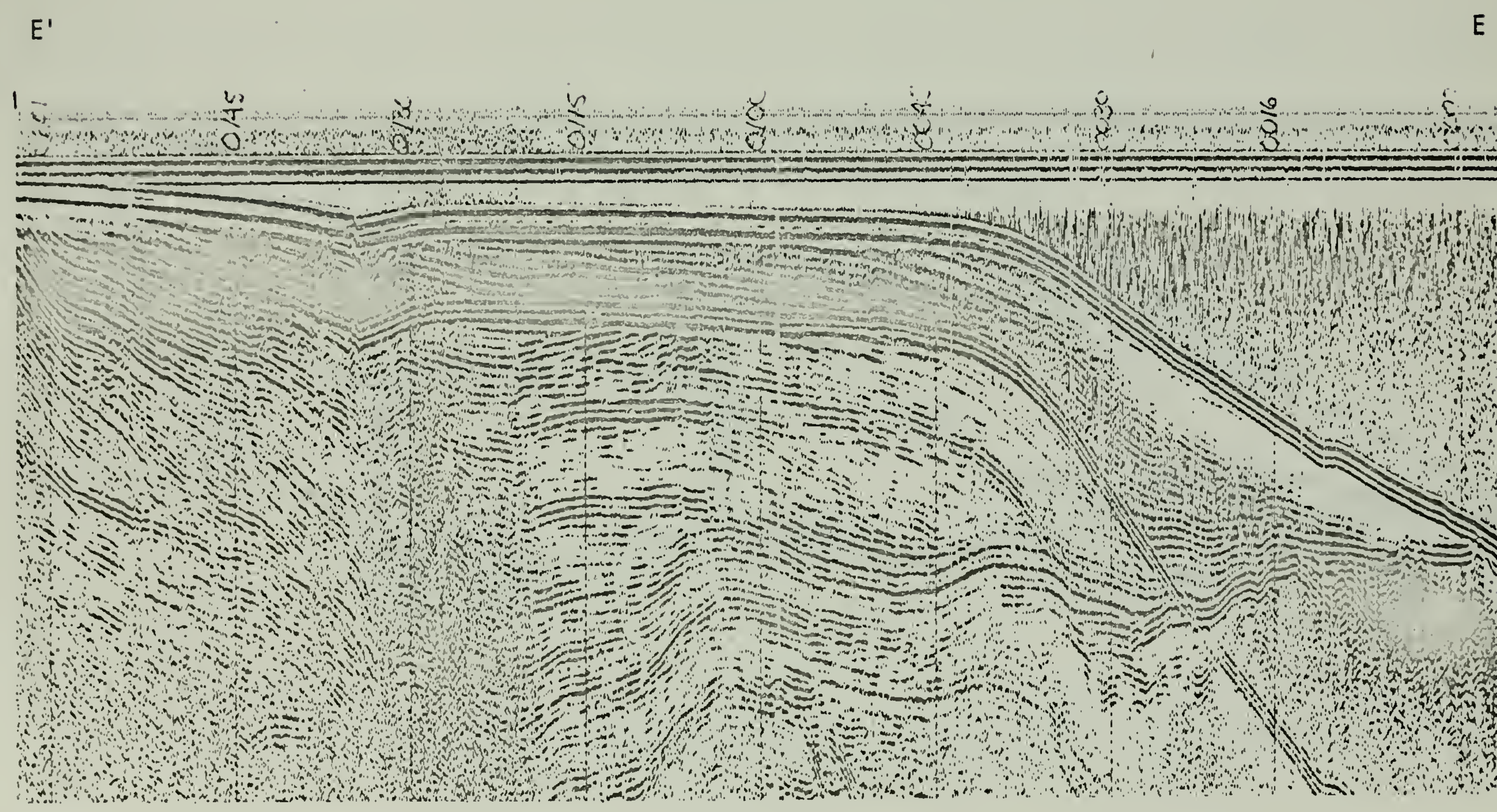

Figure 13. Profile E E' Seismic Record.

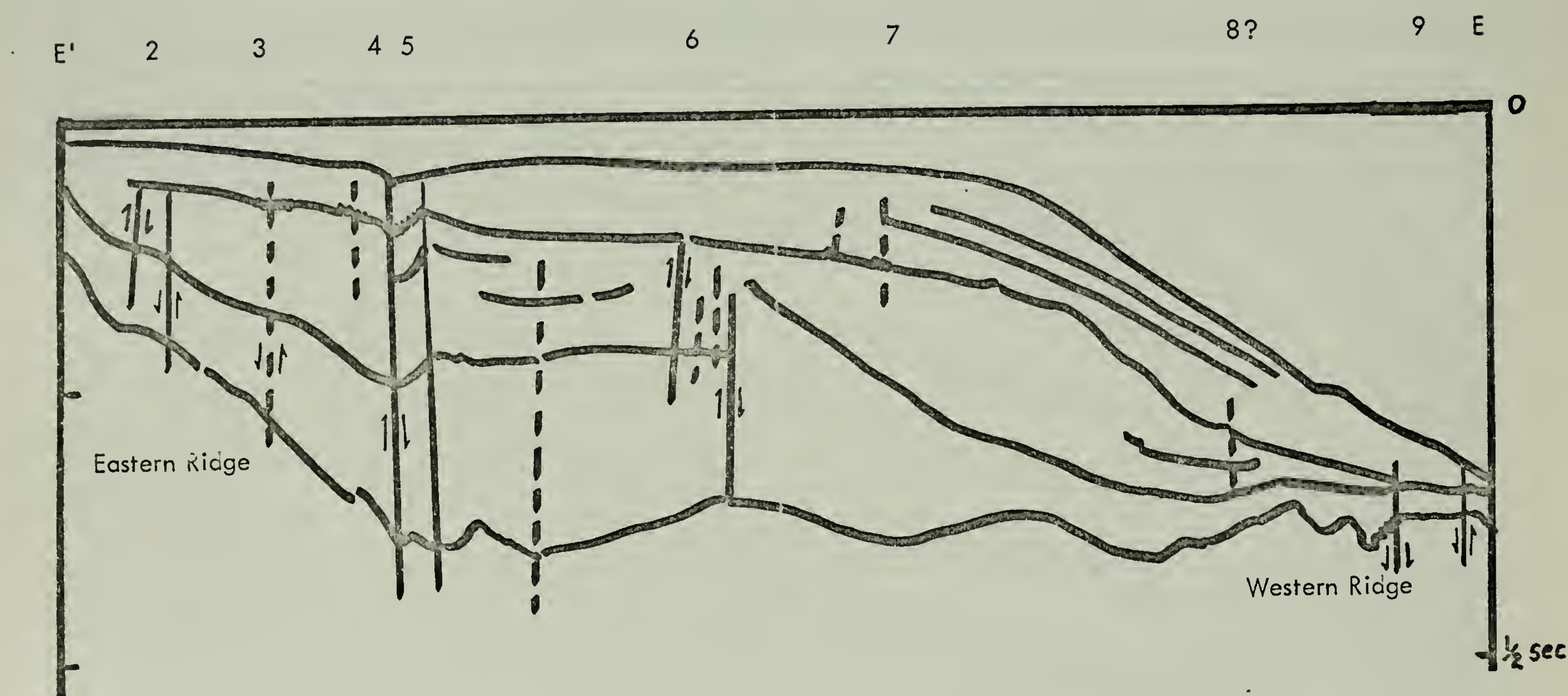

Figure 14. Profile E E' Line Drawing.

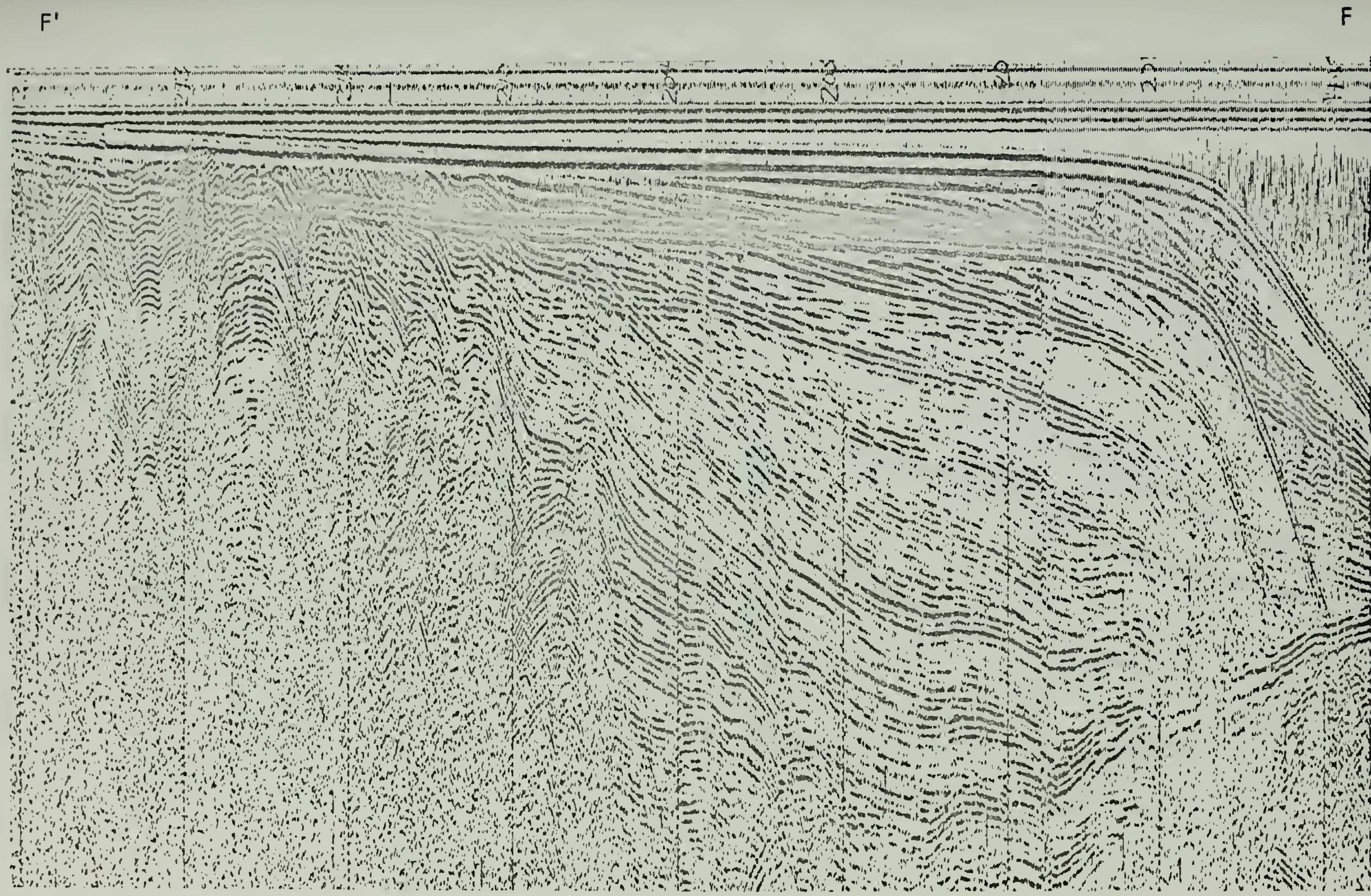

Figure 15. F F' Seismic Record.

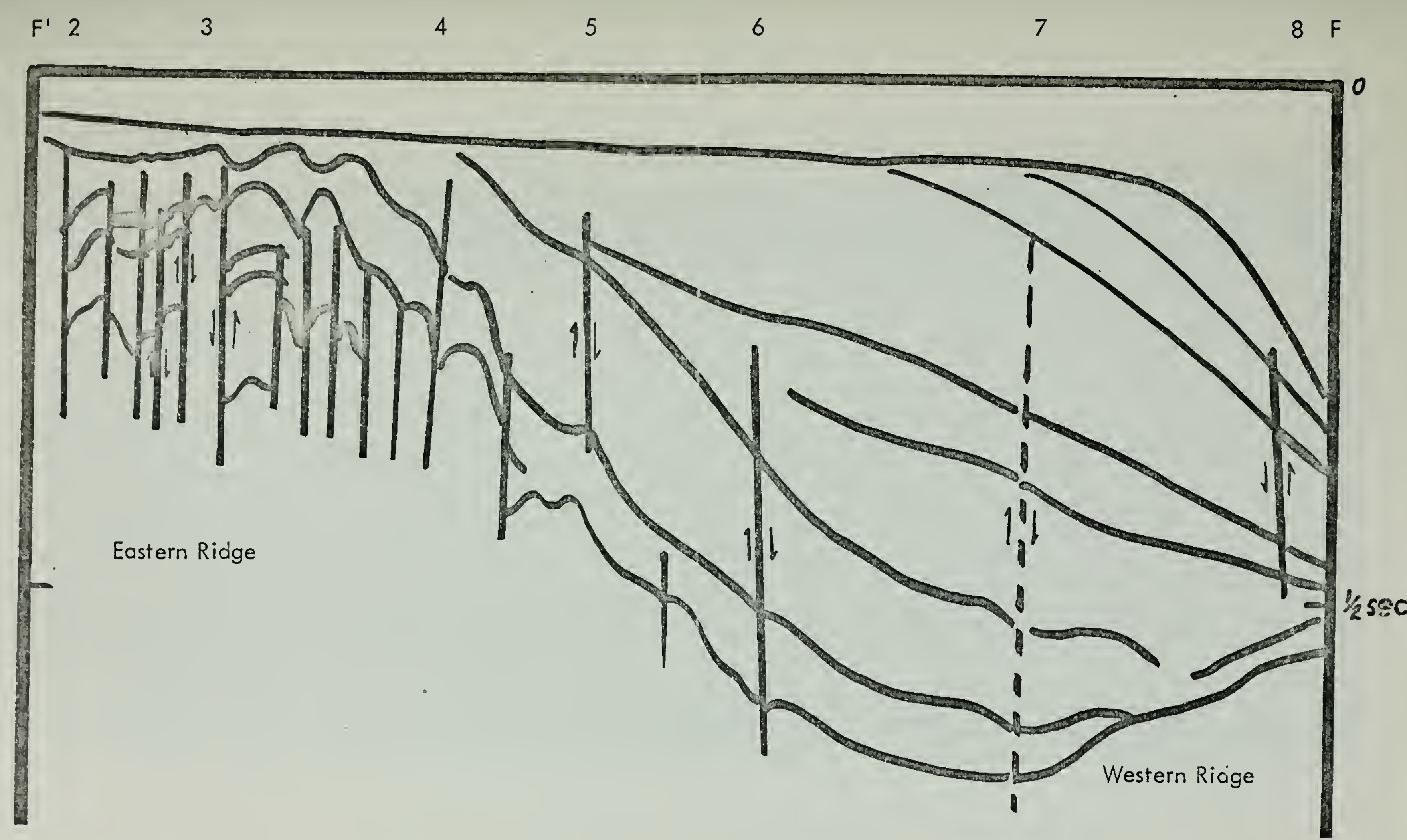

Figure 16. Profile F F' Line Drawing.

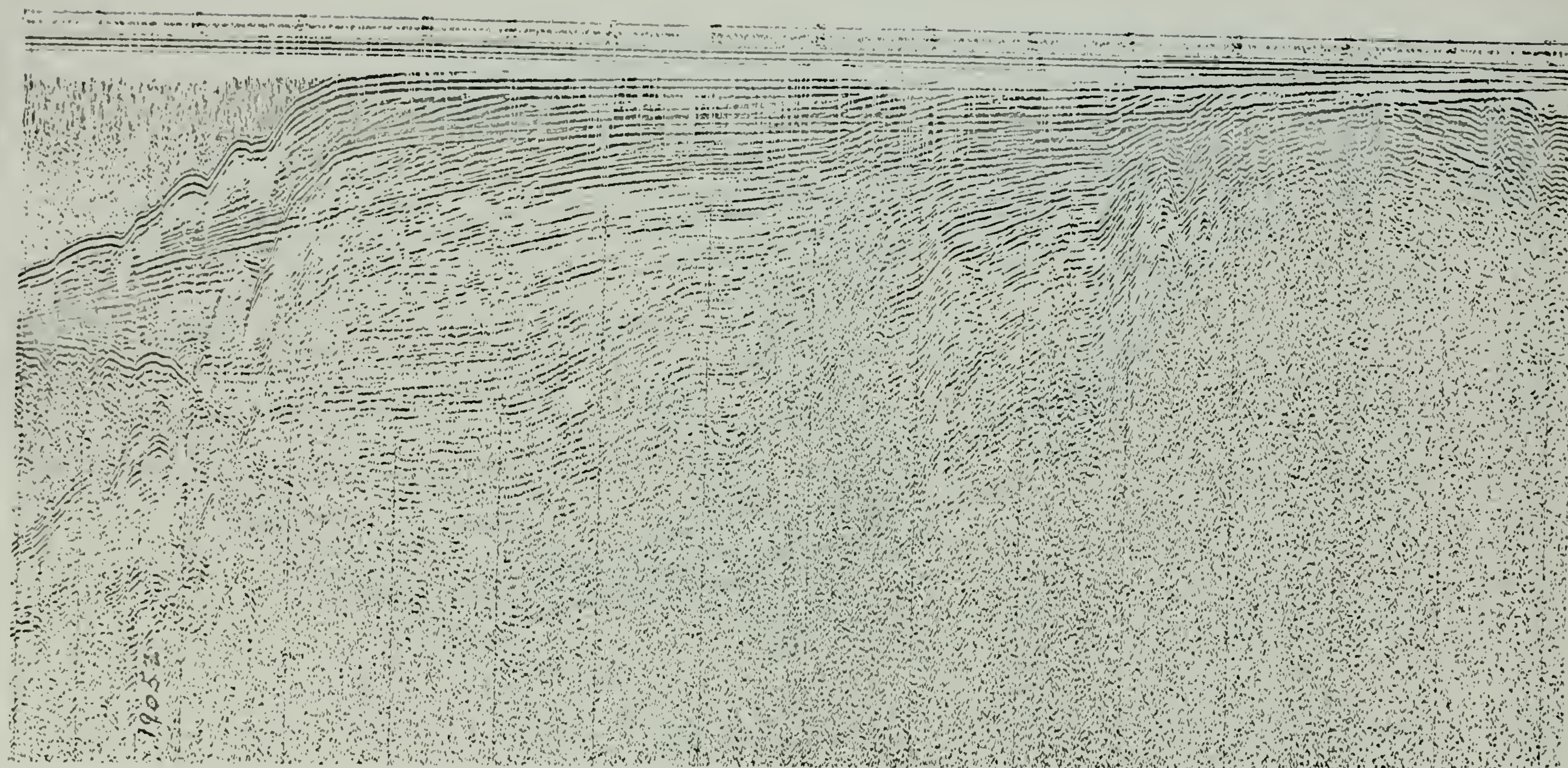

Figure 17. Profile G G' Seismic Record.

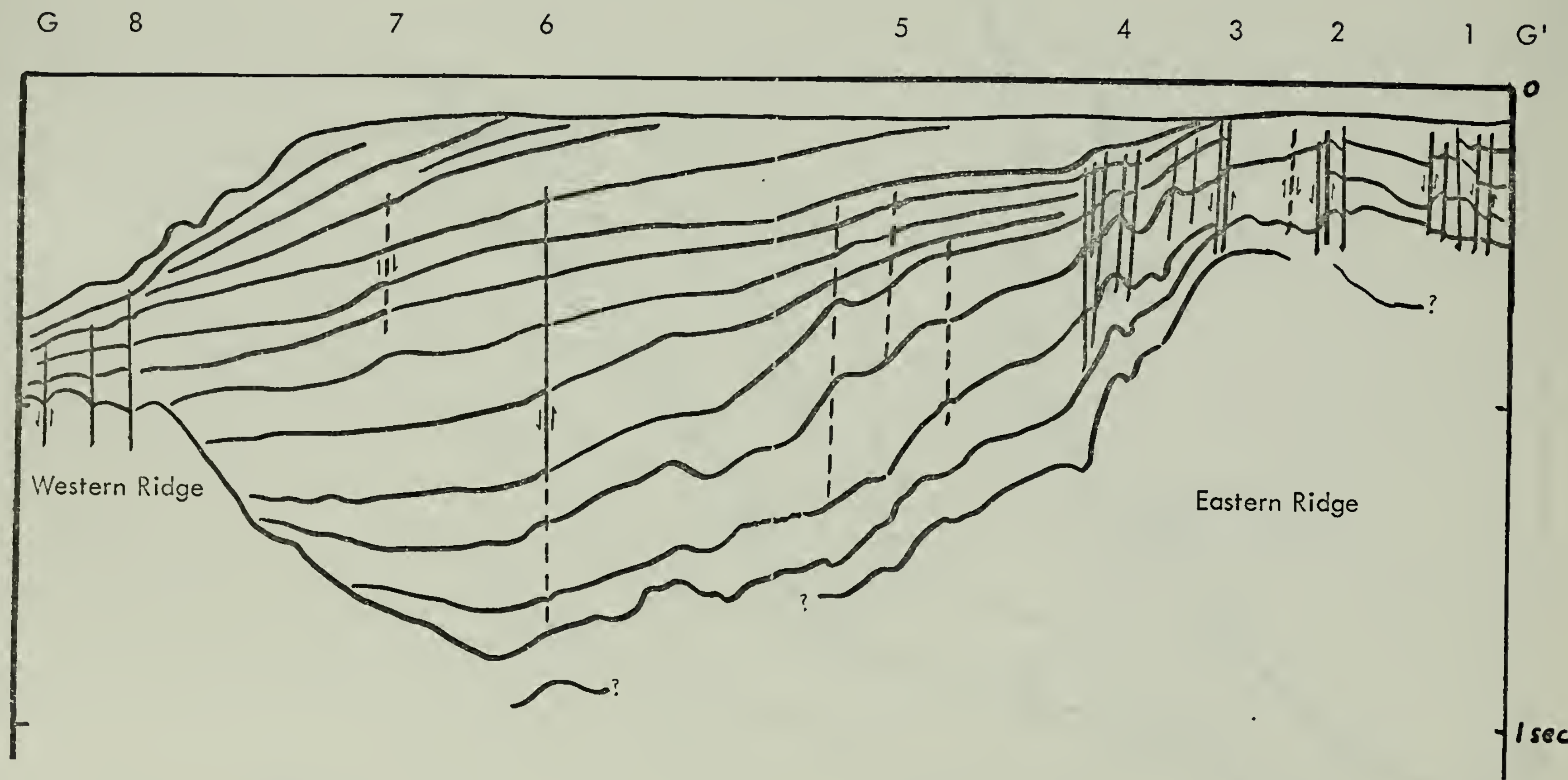

Figure 18. Profile G G' Line Drawing.

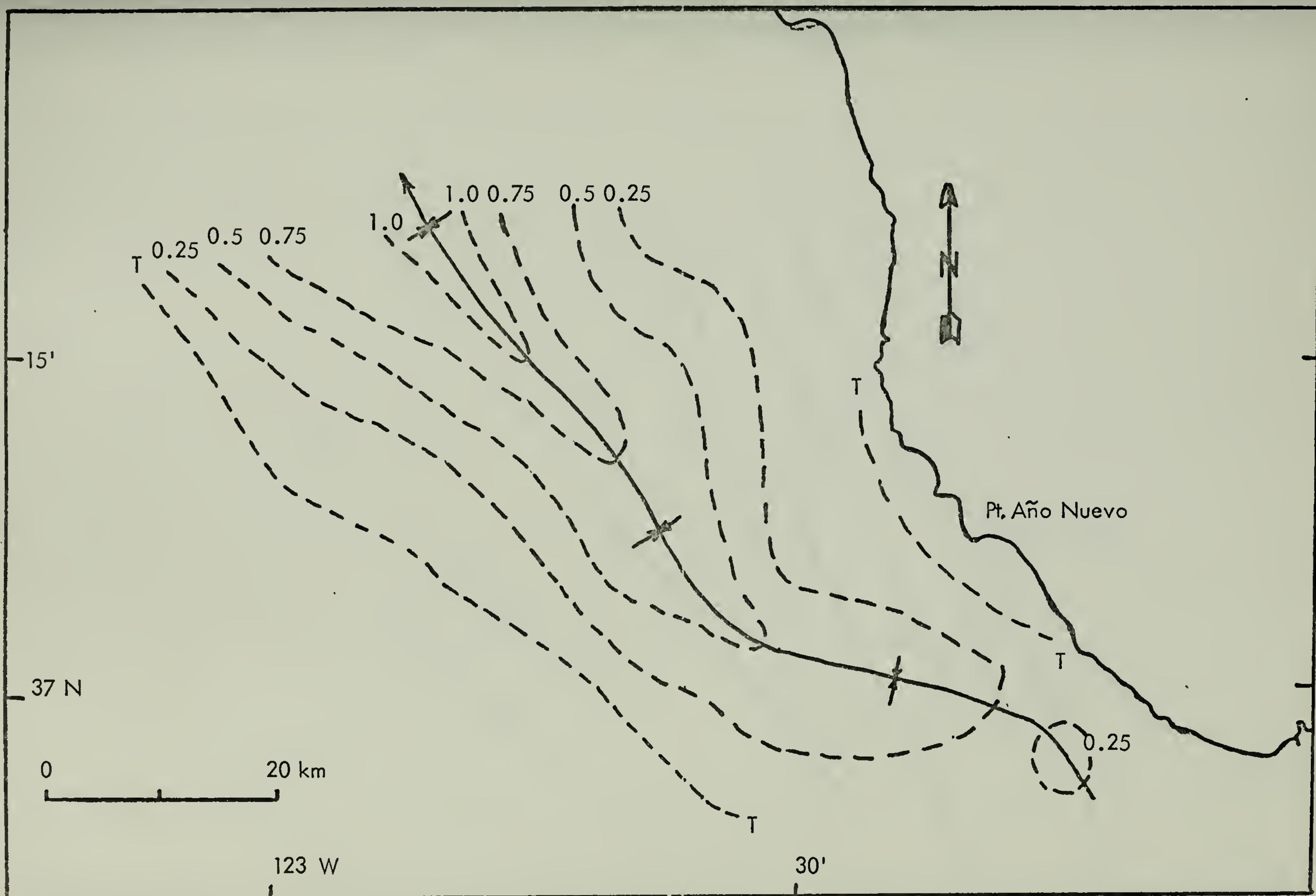

Figure 19. Structure Contour Map of Apparent Basement. One-way travel time in seconds.

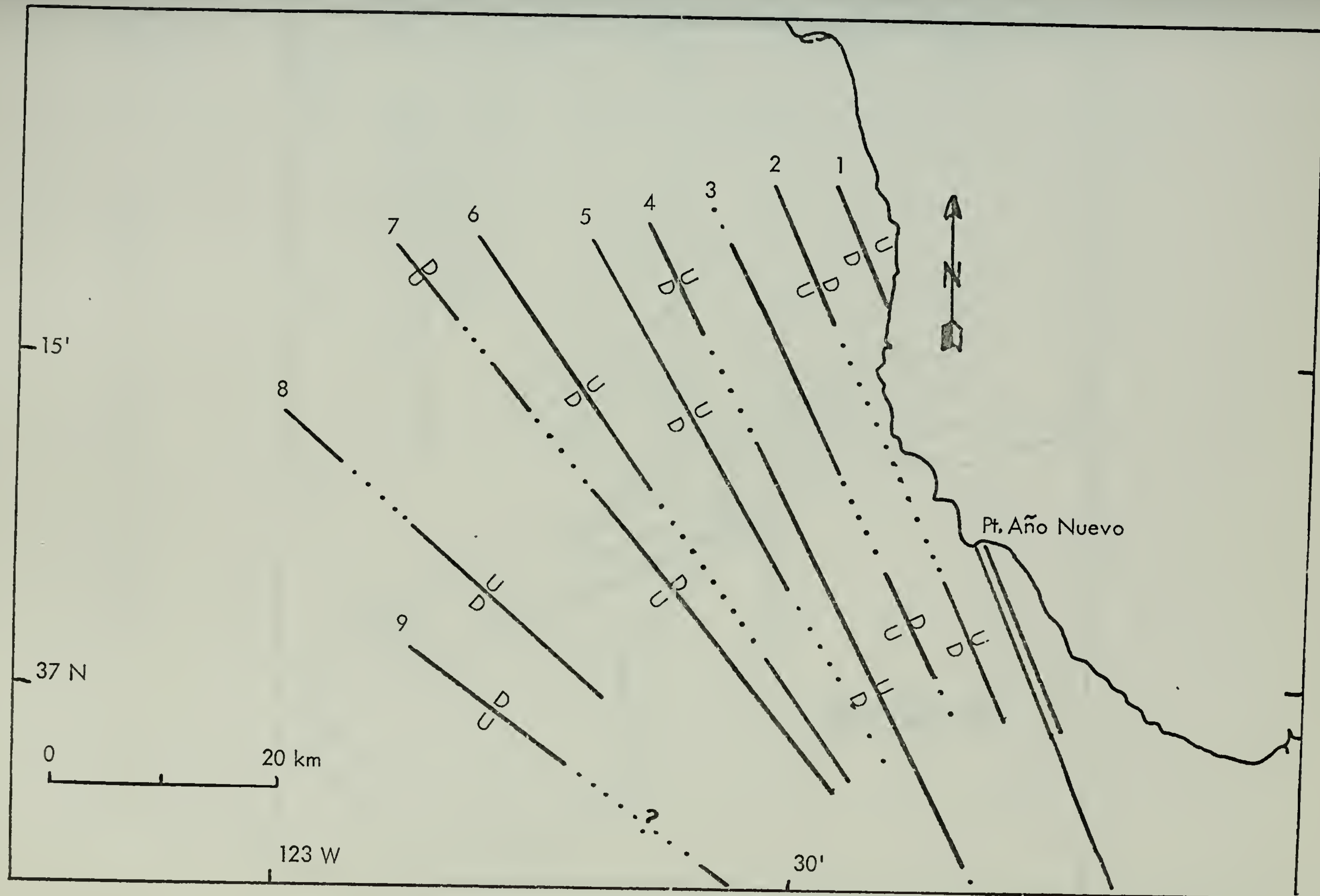

Figure 20. Location of Faults.

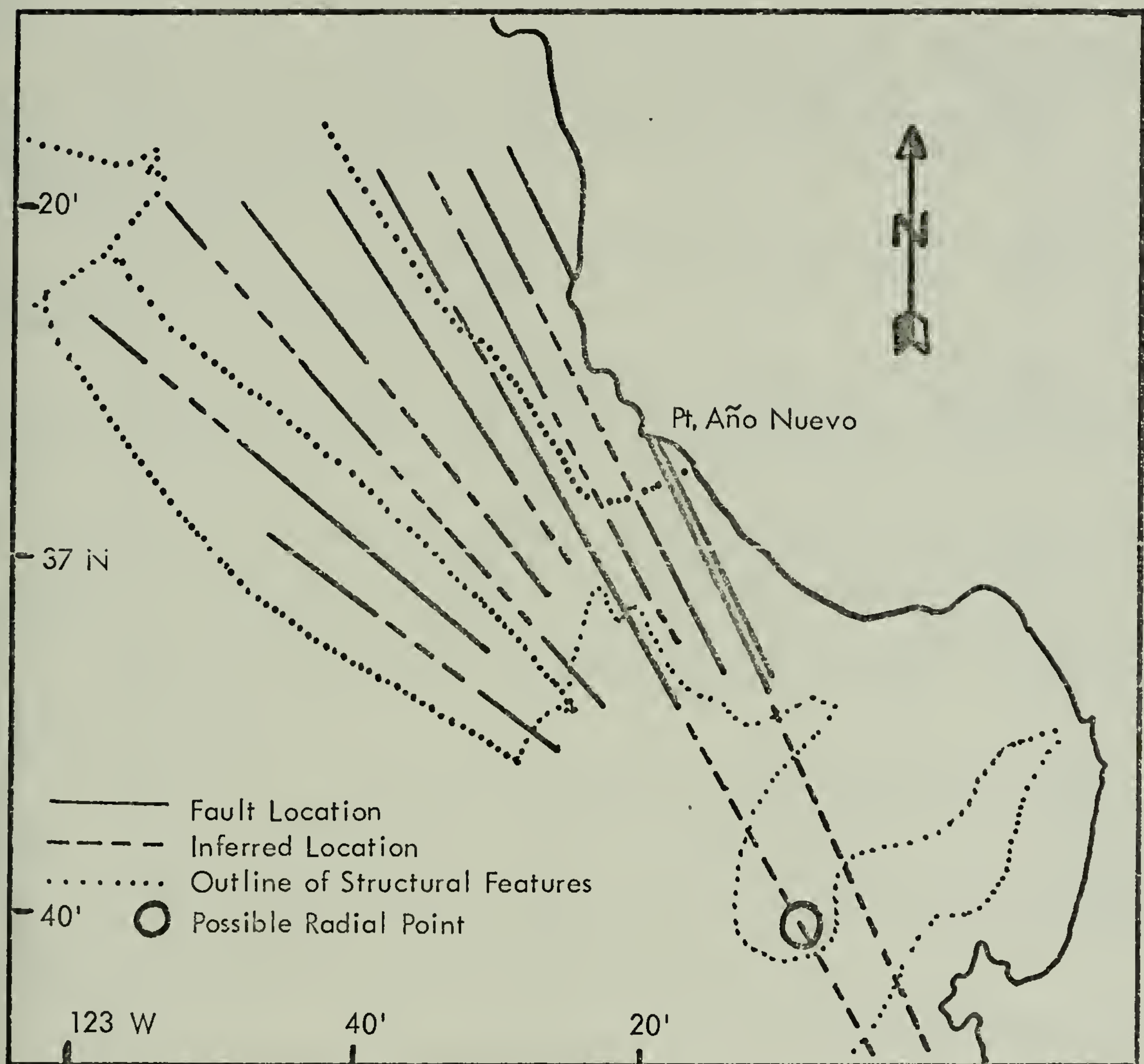

Figure 21. Summary Map Showing Relationship of Faults to Possible Radial Point and Structural Features.

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